

STUD-CONE BUMP FOR PROBE TIPS  
USED IN KNOWN GOOD DIE CARRIERS

[0001] **CROSS REFERENCE TO RELATED APPLICATIONS**

This application is related to Serial No. (TI-22561), the contents of which are incorporated herein by reference.

[0002] **FIELD OF THE INVENTION**

This invention relates to a known good die (KGD) carrier membrane and to a method of fabricating the membrane.

[0003] **BRIEF DESCRIPTION OF THE PRIOR ART**

At present, the known good die carrier industry is limited by the pad pitch and number of bumps that can be placed economically upon a single temporary test carrier used to manufacture KGD. A great deal of development work has been performed on this problem. It has been demonstrated that the use of a polymer membrane with plated bumps is a technology that could not be easily developed. The use of a conductive polymer that is screened upon the ceramic membrane is limited by the pitch constraints of the screening techniques which are pushed to the maximum at about 4 mils. This is insufficient to support the newer generation of semiconductor devices.

[0004] A further problem encountered is the cost associated with the procuring of membranes used to route the signals in the test carriers. The membranes include

conductive paths to the test contactor from conductive bumps that interface with the die product. The cost of fabricating such membranes is presently not economically viable.

[0005] **SUMMARY OF THE INVENTION**

In accordance with the present invention, the problems inherent in the prior art are minimized and there is provided a bumping technology the meets the pitch requirements of the evolving semiconductor products and which can be placed upon a low cost membrane with electrically conductive traces thereon that mirror the test carrier requirements. The technology for providing the bump is provided in the form of gold ball bond stud bumps. Stud bumps are capable of being produced to the tightest pitch that a gold ball bond can be placed on a semiconductor device. The stud bump has a fair degree of planarity within about 12 microns under present technology. This can be improved by coining the top of the stud bump with a hard metal surface. The stud bump is bonded to a low cost silicon or ceramic membrane which will fit into the KGD carrier. In order to obtain compliance and coplanarity upon the top of the stud bump for interface with the semiconductor device to be tested, the stud bump is coated with a solution of electrically conductive polymer. The electrically conductive polymer is the "cone" portion of the stud cone bump. The electrically conductive polymer over the stud bump provides the bump with the necessary compliance to conform to the surface of the semiconductor die to be tested. The electrically conductive polymer is filled with a material that forms a jagged edge on top of the cone that breaks the oxide present on the

die bond pads. This material can be electrically conductive or non-conductive, so long as the bump is electrically conductive. Silver flakes have been found to work well as the filling material. The electrically conductive polymer develops coplanarity across the surface of the test membrane the first time the device is loaded into the carrier. The electrically conductive polymers used are ones that are readily available and are well known. The stud bumping on the membranes is performed with a standard gold ball bonder. The cone is applied by dipping the tips of the stud bumps into a bath of the electrically conductive polymer to provide a thin film of the electrically conductive polymer over the cone.

[0006] The stud cone bump uses a gold ball bonded stud bump as the foundation for the contact. Over the stud bump base is a cap of an electrically conductive polymer placed over the tip of the bump and having a thickness of from about 3.5 to about 4 mils, this thickness not being critical but requiring sufficient compliance to avoid damage to the chip to which it will be in contact. The stud bump is formed on the membrane by standard ball bonding techniques, coined if desired to provide planarity of the top surface of the bump and then dipped into a solution of electrically conductive polymer which cover the top portion of the bump and extends about half way down the cone and about 2 mils from the membrane, though these dimensions also are not critical. The electrically conductive polymer includes a compliant polymer material which is filled with flakes of a material that has sharp hard edges of the type capable of breaking through the oxide formed on semiconductor bond pads. The flakes are generally from about 1 micron to about 20 microns and preferably about 3 microns. Silver flakes are preferred with the polymer preferably being filled with from about 30% to about 90% and preferably about

75% by volume silver flakes. The filler material will vary in the size of particles and proportion of fill. Those cognizant of with the art will use the filler to serve as a backbone for the filler flakes so that they may break through the oxide upon the die product which prevents conduction of current. The thickness of the polymer coating is from about 1 micron to about 20 microns and preferably about 5 microns. The hard silver flakes provide the dual functions of being electrically conductive and breaking through any oxide buildup on the die product bond pads so that electrical conduction can occur at the bump surface. Other KGD test carrier bumping technologies rely upon electro-deposited bumps or screened on electrically conductive polymers. Both of these technologies are excluded due to the financial considerations discussed hereinabove.

[0007] A principal feature of this invention lies in the utilization of proven prior art technologies in the flip chip bonding, stud bumping and polymer interconnection fields. These technologies, when used for KGD application, are unique both alone as well as in the combination.

[0008] Advantages of the above described improvement are lower carrier membrane production costs relative to the prior art and greater ease of manufacture.

[0009] **BRIEF DESCRIPTION OF THE DRAWINGS**

FIGURE 1 is a partly exploded view of a package in accordance with the present invention;

[0010] FIGURE 2 is a flow diagram showing fabrication of the membrane 9;

[0011] FIGURE 3 shows an enlarged view of a portion of the membrane 9 which includes the bond pad 25 over which is the gold bump 27 with the filled epoxy 33 covering the upper surface of the gold bump to form the stud 15 of FIGURE 1; and

[0012] FIGURE 4 shows an enlarged view of a cross section of a portion of the package of FIGURE 1.

FIG. 1

[0013] **DESCRIPTION OF THE PREFERRED EMBODIMENT**

Referring to FIGURE 1, there is shown a package which includes a header or carrier 1 having a cavity 3 with a plurality of terminals 5 disposed along the sidewalls of the cavity. The terminals 5 are coupled through an interconnect which extends through the wall of the header 1 to external leads 7 of the type shown in the above noted copending applications. A membrane 9, preferably of ceramic or silicon, is disposed on the floor of the cavity 3, the membrane having bond pads 11 thereon which are coupled by wires 13 to the terminals 5. The membrane 9 also includes thereon a plurality of stud bumps 15 with interconnect 17 connecting the stud bumps to the bond pads 11. A semiconductor die 19 having bond pads (not shown) on the underside thereof is disposed within the cavity 3 and over the membrane 9 so that the bond pads on the semiconductor die contact the studs 15 as will be explained in greater detail hereinbelow. A compliant material 21 is disposed in the cavity and over the die 19 and a temporary lid 23 is disposed over the compliant material and is desired to apply a sufficient force to the compliant material and die to cause good contact to be made between the bond pads on the die and the studs.

[0014] With reference to the membrane 9 as shown in FIGURE 2, the bond pads 11 and interconnect 17 are formed in standard manner. The studs 15 are formed on the membrane or substrate 9 as shown in the process flow of FIGURE 2 wherein the substrate 9 has the interconnect 17 and bond pads 11 and well as bond pads 25 formed in standard manner. The bond pads 25 are located where the studs 15 will be formed. Gold bumps 27 are then formed over the bond pads 25 by making a standard ball bond over the bond pad 25 and then breaking the wire extending to the ball bond in standard manner,

resulting in a gold ball over the bond pad 25. In the event the top portions of the balls are not sufficiently planar, the top surfaces are then coined 29 to improve the planarity of the top surfaces of the gold bumps. The membrane 9 is then dipped into a bath 31 containing a viscous epoxy, preferably with electrically conductive silver flakes of about three micron diameter so that the top and the surface of the sidewalls about half the distance down to the membrane 9 is covered with the filled epoxy. Preferably, the uncovered portion of the bump surface is about 2 mils in height, the covered portion is from about 1 to about 2 mils in height and the bump is about 3 to about 4 mils in diameter at the membrane. The thickness of the filled epoxy is preferably about 5 microns. The membrane 9 is now completed for use as shown in FIGURE 1, having a compliance at the epoxy region of about 30 percent.

[0015] FIGURE 3 shows an enlarged view of a portion of the membrane 9 which includes the bond pad 25 over which is the gold bump 27 with the filled epoxy 33 covering the upper surface of the gold bump to form the stud 15 of FIGURE 1.

[0016] FIGURE 4 shows an enlarged view of a cross section of a portion of the package of FIGURE 1 wherein there is shown a ceramic package 1 having the membrane 9 in the base of the cavity 3 with interconnect 17 couple via bond wire 13 to terminals 5 on the walls of the cavity. The stud bump 15 includes a gold ball 27 bonded to pad 25 with filled epoxy 33 covering the top portion of the ball. The top portion of the ball is planar, the planarity either being originally provided or provided by coining and is in contact with a bond pad 35 of the semiconductor die 19. The compliant material 21 and lid 23 are disposed over the die 19 as shown in FIGURE 1.

[0017] Though the invention has been described with reference to a specific preferred embodiment thereof, many variations and modifications will immediately become apparent to those skilled in the art. It is therefore the intention that the appended claims be interpreted as broadly as possible in view of the prior art to include all such variations and modifications.

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